

ARTICLE

Lung cancer: assessing resectability

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Abstract

Staging classification in patients with non-small cell lung cancer does not always correlate perfectly with surgical resectability. Therefore, it is important to evaluate individual features of a patient's tumor in order to determine if surgical resection is the optimal method of treatment, regardless of tumor stage. Such features include characteristics of the primary tumor, regional lymph nodes and distant sites.

Keywords: Lung neoplasms; lung surgery.

Introduction

The TNM staging system for non-small cell lung cancer (NSCLC), revised in 1997 by the American Joint Committee on Cancer, is based upon groupings of prognostically similar subsets of disease^[1]. However, these groupings do not always predict surgical resectability. Stage I and II disease is generally resectable, and Stage IV disease is almost always unresectable. However, some patients with Stage IIIa or IIIb disease have resectable tumors, and others have inoperable disease. Therefore, from a practical viewpoint, it is not sufficient to simply assign a stage when making therapeutic decisions. Rather it is important to evaluate individual features of the tumor, as outlined below.

Approximately 20% of patients with newly diagnosed NSCLC are unresectable due to distant metastatic disease (Stage IV)^[2]. In addition, patients with Stage IIIb disease are potentially unresectable, and a fair proportion of Stage IIIa disease patients have unresectable, bulky nodal disease. Thus, a large proportion of patients have unresectable disease, and signs of unresectability are found very commonly on preoperative imaging studies.

Types of resection

Most lung cancer resections are performed using lobectomy; pneumonectomy is occasionally necessary

when lobectomy is insufficient for total tumor removal. A pneumonectomy is generally indicated when tumor crosses the major fissure, leading to involvement of both upper and lower lobes. Tumor involvement of hilar structures, such as the main pulmonary artery, both superior and inferior pulmonary veins, and/or a mainstem bronchus usually necessitates a pneumonectomy. An exception may occur in tumors involving the mainstem bronchus that are amenable to lobectomy using sleeve resection and bronchoplasty; similarly, involvement of a main pulmonary artery may be amenable to lobectomy and arterioplasty.

A patient is considered to have unresectable disease if pneumonectomy is needed for complete tumor removal, yet he/she is unable to tolerate a pneumonectomy, for example due to severe cardiac disease, poor pulmonary reserve, or other medical factors.

Primary tumor

Mediastinum

Despite its T4 staging designation, minimal tumor invasion through the mediastinal pleura into fat is generally resectable. On the other hand, significant mediastinal fat invasion is usually considered a contraindication to resection. CT criteria that have been used to diagnose mediastinal invasion include >3 cm contact between

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the tumor and the mediastinum, abnormal soft tissue opacity infiltrating into mediastinal fat, and adjacent pleural or pericardial thickening (Fig. 1). Unfortunately, CT is inaccurate in excluding and in diagnosing mediastinal fat invasion, unless there are gross findings. It has been reported that induced pneumothorax and inspiration/expiration CT may occasionally be helpful in excluding mediastinal invasion.

Invasion of a vital mediastinal structure (for example, heart, great vessels, aorta, esophagus, vertebra, or trachea) is usually a contraindication to surgical resection. Reported imaging criteria for invasion include $>90^\circ$ contact with the aorta, obliteration of the fat plane between the mass and mediastinal structures, and presence of mass effect on adjacent mediastinal structures. CT and MR appear to be fairly equivalent in diagnosing invasion of such mediastinal structures, although some authors believe that MR may have a slight advantage. However, both modalities show low accuracy in this setting, primarily because it is often difficult to distinguish contiguity from invasion^[3,4].

Exceptions to the rule that invasion of a vital mediastinal structure contraindicates surgery do occur. For example, a tumor that has invaded the carina and the distal 3–4 cm of trachea can sometimes be resected with pneumonectomy and sleeve bronchoplasty (end-to-end anastomosis between contralateral mainstem bronchus and trachea). Minimal left atrial invasion, adjacent to insertion of pulmonary veins, may be resectable (Fig. 2). In addition, tumor extension into the intrapericardial portions of right or left pulmonary arteries may be resectable if a long enough segment of uninvolved artery remains for cross-clamping. Regarding aortic involvement, a neoplasm that has invaded the adventitia may be resectable if intra-adventitial dissection is possible. Superior vena caval invasion is sometimes amenable to surgery using primary suturing, patch grafting, or bypass grafting. Finally, minimal vertebral body invasion may be resectable en bloc.

Chest wall

In general, chest wall invasion does not imply unresectability. However, the combination of chest wall invasion and mediastinal lymph node metastases portends a poor prognosis, and therefore most surgeons will not operate on patients with these proven features. The only reliable criterion for diagnosing chest wall invasion using CT is frank soft tissue in the chest wall with or without rib or spine destruction. Induced pneumothorax and inspiration/expiration CT may be helpful in excluding chest wall invasion, although these techniques are not commonly performed^[5–7]. Although CT and MR are fairly equivalent in evaluating for chest wall invasion, MR is better in assessing superior sulcus tumors. If superior sulcus invasion is diagnosed, such a patient is usually treated using radiation therapy and chemotherapy, prior to surgery.

Pleura and pericardium

Patients with malignant pleural or pericardial effusions are not felt to be surgical candidates. CT criteria include pleural soft tissue thickening and/or nodules.

Mediastinal lymph nodes

It should be remembered that mediastinal lymph node size does not necessarily correlate well with the presence or absence of lymph node metastases; lymph nodes may be enlarged due to benign causes and small lymph nodes may harbor microscopic metastases. In fact, CT and MR have been reported to show low accuracy in diagnosing nodal metastatic disease^[3,4,8,9]. Therefore, the rules regarding mediastinal nodal metastases and unresectability require better proof of nodal status than is available using such conventional imaging techniques. Generally, cytologic or histologic biopsy proof of nodal metastases is necessary to determine that a patient is not a surgical candidate.

Patients with proven ipsilateral mediastinal lymph node metastases (N2 disease) are generally considered to have resectable disease, unless the involved lymph nodes are bulky or there is extracapsular nodal tumor spread. However, patients with N2 disease are often treated with chemotherapy and radiation therapy prior to surgery; therefore preoperative diagnosis of nodal disease is important. In contrast, patients with proven N3 disease (metastasis in contralateral hilar, contralateral mediastinal, ipsilateral or contralateral scalene or supraclavicular lymph nodes) are generally considered to have unresectable disease. A rare exception may occur in patients with nodal disease that regresses after chemotherapy and radiation therapy.

Distant metastases

Distant metastases almost always indicate primary tumor unresectability. Distant sites most commonly include brain, bone, liver and adrenals, in decreasing order of frequency^[2]. Brain metastases are often an isolated finding; if isolated, both the primary tumor and the metastasis may be resectable. On the other hand, isolated liver metastases are rare; therefore dedicated liver CT is usually unnecessary, if a complete chest CT (including the adrenal glands) has been performed. If an adrenal mass is detected on a chest CT, then the patient should be brought back at a later date for dedicated adrenal scanning. The vast majority of adrenal masses detected at CT are benign adrenal cortical adenomas, and most adenomas are diagnosable using dedicated adrenal CT or MR scanning^[10].

A separate tumor nodule (of the same histology as the primary) in another lobe of the patient's lungs is categorized as distant metastatic disease (M1). Although

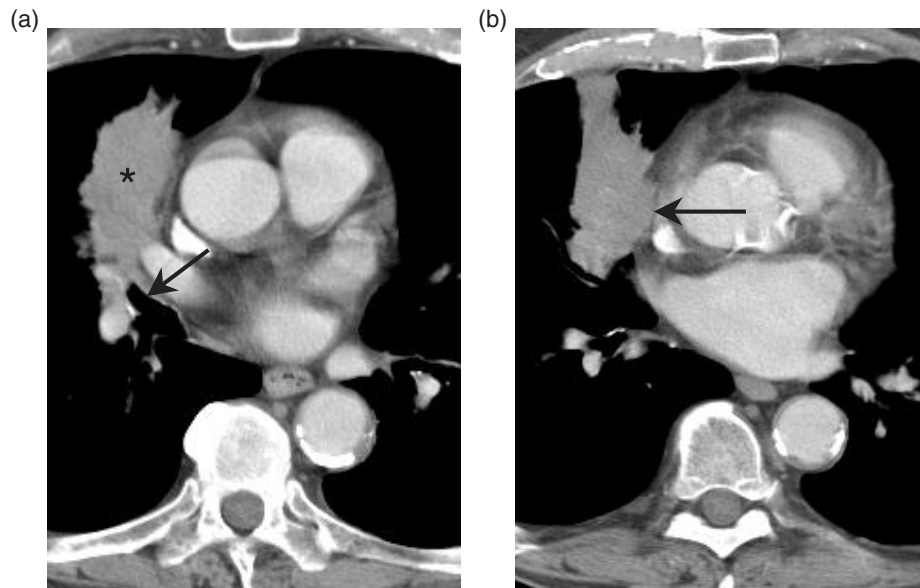


Figure 1 NSCLC (*) adjacent to the middle lobe bronchus (arrow in (a)). Surgically proven minimal tumor extension through the pericardium into mediastinal fat (arrow in (b)). The tumor was successfully resected using a middle lobe sleeve lobectomy.

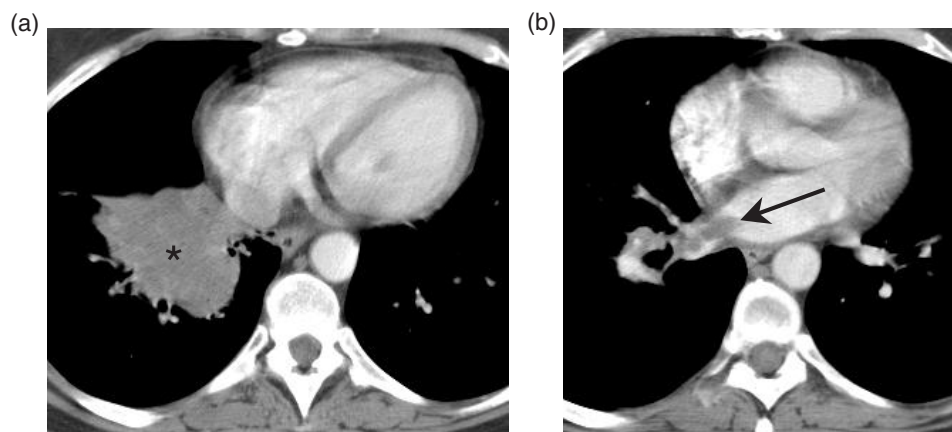


Figure 2 NSCLC (*) invading into the left atrium via the right inferior pulmonary vein (arrow). Minimal tumor extension into the atrial lumen is sometimes resectable.

technically these patients are not surgical candidates due to the presence of a distant metastasis, in fact there is considerable controversy regarding treatment in this situation. It is possible that, in some patients, the nodule actually represents a second primary tumor. Some surgeons opt to resect the larger tumor using a lobectomy and the smaller lesion using a wedge resection, when technically feasible.

Other imaging studies

Whole body PET scanning has become extremely useful in assessing for disease indicative of unresectability that is occult on CT. Different institutions use PET to varying degrees, depending upon the availability of the

technology. PET is quickly becoming a routine test at many institutions in patients with newly diagnosed or suspected NSCLC. However, as with CT, if the PET study suggests the presence of distant metastases or N3 disease, biopsy proof is needed before declaring the patient to be unresectable, because false positive PET findings do occur. Bone scanning and head CT and MR are generally reserved for patients with signs and/or symptoms of metastatic disease, because of their low yield in the absence of such signs or symptoms.

Conclusion

It is important to evaluate individual features of a patient's tumor in order to determine if surgical resection is the optimal method of treatment. A patient should not be

denied potentially curative surgery based upon unproven and/or equivocal imaging findings.

Key points

- (1) Staging classification does not correlate perfectly with surgical resectability.
- (2) Due to the use of new surgical techniques, invasion of a vital mediastinal structure does not necessarily indicate unresectability.
- (3) A patient should not be denied potentially curative surgery based upon unproven and/or equivocal imaging findings.

References

- [1] Mountain CF. Revisions in the International System for Staging Lung Cancer. *Chest* 1997; 111: 1710–7.
- [2] Quint LE, Tummala S, Brisson LJ *et al.* Distribution of distant metastases from newly diagnosed non-small cell lung cancer. *Ann Thorac Surg* 1996; 62: 246–50.
- [3] Gdeedo A, Van Schil P, Corthouts B, Van Mieghem F, Van Meerbeeck J, Van Marck E. Prospective evaluation of computed tomography and mediastinoscopy in mediastinal lymph node staging. *Eur Respir J* 1997; 10: 1547–51.
- [4] Webb WR, Gatsonis C, Zerhouni EA *et al.* CT and MR imaging in staging non-small cell bronchogenic carcinoma: report of the Radiologic Diagnostic Oncology Group. *Radiology* 1991; 178: 705–13.
- [5] Watanabe A, Shimokata K, Saka H, Nomura F, Sakai S. Chest CT combined with artificial pneumothorax: value in determining origin and extent of tumor. *Am J Roentgenol* 1991; 156: 707–10.
- [6] Yokoi K, Mori K, Miyazawa N, Saito Y, Okuyama A, Sasagawa M. Tumor invasion of the chest wall and mediastinum in lung cancer: evaluation with pneumothorax CT. *Radiology* 1991; 181: 147–52.
- [7] Yokozaki M, Nawano S, Nagai K, Moriyama N, Kodama T, Nishiwaki Y. Cine magnetic resonance imaging, computed tomography and ultrasonography in the evaluation of chest wall invasion of lung cancer. *Hiroshima J Med Sci* 1997; 46: 61–6.
- [8] McLoud TC, Bourgouin PM, Greenberg RW *et al.* Bronchogenic carcinoma: analysis of staging in the mediastinum with CT by correlative lymph node mapping and sampling. *Radiology* 1992; 182: 319–23.
- [9] Kernstine KH, Stanford W, Mullan BF *et al.* PET, CT, and MRI with Combidex for mediastinal staging in non-small cell lung carcinoma. *Ann Thorac Surg* 1999; 68: 1022–8.
- [10] Caoili EM, Korobkin M, Francis IR *et al.* Adrenal masses: characterization with combined unenhanced and delayed enhanced CT. *Radiology* 2002; 222: 629–33.